

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
18 April 2002 (18.04.2002)

PCT

(10) International Publication Number
WO 02/30295 A1

- (51) International Patent Classification⁷: **A61B 17/04, 17/08**
- (21) International Application Number: **PCT/US01/31709**
- (22) International Filing Date: **10 October 2001 (10.10.2001)**
- (25) Filing Language: **English**
- (26) Publication Language: **English**
- (30) Priority Data:
09/686,004 10 October 2000 (10.10.2000) US
- (71) Applicant (*for all designated States except US*): **COALESCENT SURGICAL, INC. [US/US]; 559 East Weddell Drive, Sunnyvale, CA 94089 (US).**
- (72) Inventors; and
- (75) Inventors/Applicants (*for US only*): **NGUYEN, John, D. [US/US]; 4053 Forestwood Drive, San Jose, CA 95121 (US). SCHALLER, Laurent [CH/US]; 595 Benvenue Avenue, Los Altos, CA 94024 (US). HILL, Art [US/US]; 2476 20th Avenue, San Francisco, CA 94116 (US).**
- (74) Agent: **MACEY, Harry, J.; P.O. Box 475845, San Francisco, CA 94147-5845 (US).**
- (81) Designated States (*national*): AE, AG, AL, AM, AT, AT (utility model), AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, CZ (utility model), DE, DE (utility model), DK, DK (utility model), DM, DZ, EC, EE, EE (utility model), ES, FI, FI (utility model), GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, I.R., LS, IT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PH, PL, PT, RO, RU, SD, SE, SG, SI, SK, SK (utility model), SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA.
- (84) Designated States (*regional*): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Declaration under Rule 4.17:

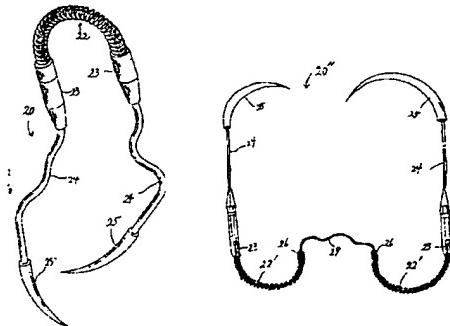
— *of inventorship (Rule 4.17(iv)) for US only*

Published:

— *with international search report*

[Continued on next page]

(54) Title: MINIMALLY INVASIVE VALVE REPAIR PROCEDURE AND APPARATUS



WO 02/30295 A1

(57) **Abstract:** A clip (22) of a self-dosing type is used for valve repair. The dip is generally U-shaped with two end points separated from each other when it is constrained to be in an open configuration, but tends to coil up to assume its natural closed configuration if the constraint is removed. At least one end point is connected through a suture to a tissue penetrating needle (25). A needle holder (30) has an outer tube (32) and an inner member (34) which has a slit (35) at the front and is slidable inside the outer tube (32). They are designed such that the slit (35) can grab the needle (25) tightly or release it as the inner member (34) is moved backward or forward with respect to the outer tube (32). With the needle (25) secured at the front, the needle holder (30) is passed through a cannula (40) inserted through an incision and the needle (25) penetrates the leaflets such that the clip (22) can be positioned with the end points hooked to the pair of leaflets to be stitched together. If the clip is released from the suture (24) thereafter, it tends to coil up, reducing the distance between the end points and pulling the leaflets together. A double-arm clip assembly (20'') with each of the end points of the clip (22') attached through a suture (24) to a separate needle (25) may be similarly used for valve repair. Such a double-arm clip assembly (20'') may contain two of such clips mutually connected by means of a flexible connector (29) such that two leaflets are held together by the connector, with the two clips (22') each anchored to a corresponding one of the leaflets.



For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

MINIMALLY INVASIVE VALVE REPAIR PROCEDURE AND APPARATUS

5 Background of the Invention

This invention relates to methods and apparatus for minimally invasive valve repair and more particularly to minimally invasive methods and apparatus for reducing the valve orifice.

Valve repair is currently done in open surgical procedures as described, for example, by F. Maisano, et al. in their article entitled "The double-orifice technique as a standardized approach to treat mitral regurgitation due to severe myxomatous disease" which appeared in European Journal of Cardio-thoracic Surgery, Vol. 17 (2000) 201-205. Cumbersome suture management, knot tying, pain and long recovery time are inherent to such open surgical procedures. It now goes without saying that minimally invasive surgery is the preferred procedure, having allowed surgeons to perform procedures with less pain and disability than open surgical procedures. Tissue-connector apparatus and methods usable in such minimally invasive surgery procedures have recently been disclosed in U.S. patent applications Series Nos. 09/089,884 and 09/090,305 both filed June 3, 1998 and Serial Nos. 09/259,705 and 09/260,623 both filed March 1, 2000 and International Application Nos. PCT/US99/12563 and PCT/US99/12566 both filed June 3, 1999 and published on December 9, 1999 under International Publication Nos. WO 99/62409 and WO 99/62406.

It is therefore a general object of this invention to provide improvement(s) in minimally invasive methods and apparatus for coaptation of leaflets in the case of regurgitation to reduce the

annular orifice. The invention also involves providing such improved minimally invasive methods and apparatus using a tissue-connector apparatus disclosed in the aforementioned U.S. and international patent applications.

5

Summary of the Invention

Methods and apparatus embodying this invention, with which improved minimally invasive methods and apparatus for coaptation of leaflets in the case of regurgitation to reduce the annular orifice and other advantages can be accomplished, are characterized as using a clip of a self-closing type as a tissue connector to capture leaflets and secure them together. Such a clip is typically U-shaped, having two end points, when it is constrained to be in an open configuration but is made of a wire of a shape memory material such that it tends to coil up to assume its natural closed configuration. Thus, if such a clip is placed between a pair of valve leaflets to be repaired, having each of its end points penetrating and completely passing through a different one of the leaflets while being constrained to be in its open configuration, and if the constraint which has been keeping the clip in its open configuration is then removed, it naturally tends to coil up, although it will not come to assume its natural closed configuration because it is hooked to the leaflets, tending nevertheless to reduce the distance of separation between its two end points. This has the effect of holding the leaflets together.

Such a clip may be deployed in the form of a clip assembly, having at least one of the end points of the clip connected to a tissue-piecing needle through a flexible member such as a suture and a

release mechanism by which the clip can be easily released. The needle is attached to the front end of a needle-holder and passed through a cannula inserted through an incision towards the valve leaflets to be repaired. The needle-holder, according to a preferred 5 embodiment of the invention, is formed with an outer tube and an inner member which is slidable inside the outer tube and is designed such that as the inner member is pushed forward against the biasing force of a spring contained in the outer tube, a slit which is provided at the front end becomes wider for accepting the needle therein but 10 as the inner member is allowed to move to a backward position, the slit becomes narrower and grips the needle tightly.

Brief Description of the Drawings

The accompanying drawings, which are incorporated in and 15 form a part of this specification, illustrate embodiments of the invention and, together with the description, serve to explain the principles of the invention. In the drawings:

Fig. 1 is a schematic view of a tissue-connector apparatus embodying this invention when it is about to be used, its double-arm 20 clip assembly being shown as a diagonal view and its needle holder being shown as a sectional side view;

Fig. 2 is an enlarged external view of the double-arm clip assembly of Fig. 1;

Figs. 2A and 2B show a release mechanism for a single-arm 25 clip assembly such as that shown in Fig. 5 or one end of a double-arm clip assembly such as that shown in Fig. 2;

Fig. 2C shows a similar release mechanism arranged for the other end of a double arm clip such as shown in Fig. 9.

Fig. 3 is an enlarged sectional view of a portion of the needle holder near its front end;

Fig. 4A is a schematic diagonal view of the clip assembly of Figs. 1 and 2 being used in a valve repair procedure embodying this invention, and Fig. 4B is another schematic diagonal view of the clip of Fig. 4A after it has been released;

Fig. 5 is an external view of a single-arm clip assembly which may be used in a method of minimally invasive valve repair embodying this invention;

10 Fig. 6 is a schematic sectional view for showing a method of valve repair embodying this invention by using the single-arm clip assembly of Fig. 5;

Fig. 7 is another clip assembly embodying this invention; and

15 Fig. 8A is a schematic sectional view of leaflets repaired by a clip assembly of Fig. 7, Fig. 8B is a top view of the leaflets of Fig. 8A, and Fig. 8C is a top view of leaflets repaired in an alternative manner.

20 Throughout herein like components are indicated by the same numerals even where they are components of different assemblies and may not necessarily described repetitiously.

The schematic drawings are intended to be indeed schematic and only to show the basic concepts of the invention, not necessarily representing realistic views, for example, with realistic relative sizes of body components and apparatus components.

25

Detailed Description of the Invention

The invention is described next by way of examples. Fig. 1 shows schematically a tissue-connector apparatus 10 embodying

this invention for a minimally invasive procedure. Described briefly, the apparatus 10 consists of a clip assembly 20 and a needle holder 30, which will be described next sequentially in detail.

- The clip assembly 20 according to this embodiment may be
- 5 referred to as the double-arm clip assembly, characterized as having a clip 22 of a self-closing type with two end points each connected through a flexible member 24 such as a suture to a tissue penetrating needle 25 (as disclosed, for example, in aforementioned U.S. patent applications Serial Nos. 09/259,705 and 09/260,623 both filed March
- 10 1, 2000, and International Application Nos. PCT/US99/12563 and PCT/US99/12566 both filed June 3, 1999 and published on December 9, 1999 under International Publication Nos. WO 99/62409 and WO 99/62406, all of which are herein incorporated by reference). Each of the needles 25 has a tissue-piercing sharp point
- 15 and is connected to a corresponding one of the flexible members 24. As shown more clearly in Fig. 2, the two end points of the clip 22 are each provided with and directly connected to a release mechanism 23 such that it can be released easily from the flexible members 24 and from being constrained to remain in its generally U-shaped open
- 20 configuration. A further description of a suitable double-arm clip assembly is provided in International Application No. PCT/US99/12566, the section and figure described from page 24, line 8 through line 14 and ending with the term "configuration" being specifically incorporated by reference herein.
- 25 In addition, and for the sake of particular example, the release mechanism description in International Application No. PCT/US99/12566 from page 25, line 12 through page 27, line 30 ending with the text "mechanism 23c" (but without the text "such as

needle 17 as shown in Fig. 1" on line 27 of page 27) and the referenced figures are hereby incorporated by reference herein. A summary of such a release mechanism is provided below with reference to Figs. 2A-C.

- 5 Referring to Figs. 2A and 2B a release mechanism 23 generally comprises a plurality of substantially rigid strands, cables or wires 106, which may be metallic, and which are arranged substantially parallel to one another and circularly about a longitudinal axis. The hidden end portions of the strands are coupled to tapered section "T", which is coupled to a piercing member or needle through a flexible member 4. The strands may be coupled to rod 162, which is fixed to the tapered element. End portions of the strands include notches, which form a chamber 108 for releasably receiving enlarged portion "E" of the clip (or fastener) wire "W."
- 10 15 According to the cited PCT application, the notches preferably are placed about 0.015 from the free ends of the strands, but this distance can be varied depending upon the desired compression on the fastener or clip spring. A shrink wrap layer, preferably a shrink tubing 110 as set forth in the cited PCT application is provided around at least the free end portions of the strands and the shrink wrap or tubing heated to compress against the strands and hold them in place against the enlarged wire portion to effectively hold the enlarged portion captive until the shrink wrap is squeezed, the strands displaced and the enlarged portion released. Referring to
- 20 25 Fig. 3C, the release mechanism may also be used to releasably couple the other end of the fastener to another flexible member and needle as shown in Fig. 2. In this arrangement, an annular member or stopper 115 is secured to the other end of the fastener or wire to

prevent the enlarged portion of the wire at this end from passing through the compression spring upon release of from the release mechanism.

- The clip 22, or a surgical fastener, of the so-called self-closing type may be one disclosed in aforementioned U.S. patent applications Series Nos. 09/089,884 and 09/090,305 both filed June 3, 1998 (herein also incorporated by reference), as well as in aforementioned U.S. patent applications Serial Nos. 09/259,705 and 09/260,623 and International Application Nos. PCT/US99/12563 and PCT/US99/12566 (both filed June 3, 1999 and published on December 9, 1999 under International Publication Nos. WO 99/62409 and WO 99/62406), characterized as having two end points, being generally U-shaped when in an open configuration (as shown in Figs. 1 and 2), being naturally in a closed configuration (state or condition) and being elastic (or pseudoelastic, but herein broadly characterized as being "elastic") so as to tend to return to the closed configuration by reducing the separation distance between its end points when forced into an open configuration. As disclosed in aforementioned U.S. patent applications Series Nos. 09/089,884 and 09/090,305, such a clip 22 may comprise a deformable wire made of a shape memory alloy such as a nickel titanium based alloy (nitinol). It is also known that the alloy may include additional elements, depending on the desired yield strength of the material or the temperature at which particular pseudoelastic or shape transformation characteristics occur. When the clip 22 is in its closed configuration (not shown) with no external restraining force thereupon, it may be in a completely closed loop with its end points in a side-by-side or overlapping orientation, the wire being looped by

more than 360°. The diameter of the wire for the clip 22 and the diameter of the loop when it is in the closed configuration may be selected, depending on the application, and do not limit the scope of the invention.

- 5 The section of International Application No. PCT/US99/12566 from page 12, line 12 through page 14, line 20 and Figs. 3A-C is specifically incorporated by reference herein (but without the text "Referring to Figs. 3-6 in line 12 of page 12; "(see e.g., Figs. 2F)" in line 25 of page 12; and "(see e.g., Fig1.)" on lines 25 and 26 of page 10 13) as further description of suitable clips.

The needle holder 30 consists essentially of a hollow outer tube 32, an inner member 34 and a spring 38, as shown in Fig. 1. The outer tube 32 is elongated, defining a longitudinal direction. The inner member 34 is also longitudinally elongated and is adapted to slide longitudinally inside the outer tube 32 and to releasably grab the needles 25, one at a time. According to the embodiment shown in Fig. 1, the inner member 34 is comprised of a knob 341 at its proximal end, a conjunction tube 342 in the middle and a needle-holding tube 343 in front. The conjunction tube 342 and the needle-holding tube 343 are laser-welded together. A threaded adapter is laser-welded to the proximal end of the conjunction tube 342 for allowing the knob 341 to be screwed thereto after the spring 38 is inserted inside the outer tube 32 such that, once the needle holder 30 is thus assembled, the knob 341, the conjunction tube 342 and the needle-holding tube 343 will move together as a single unit. The front end of the needle-holding tube 343 is provided with a longitudinally elongated slit 35 for holding the needle 25, and the outer tube 32 has a front opening 33, as shown more clearly in Fig. 15 20 25

3. The needle-holding tube 343 with the slit 35 and the front opening 33 of the outer tube 32 are so designed that the slit 35 will open and become sufficiently wide in front as the inner member 34 is pushed forward through the outer tube 32 for accepting a needle 25 (shown by broken lines in Fig. 3) therein and that the opening of the slit 35 tends to become smaller as the inner member 34 is moved backwards through the outer tube 32 so as to retract the needle-holding tube 343 through the front opening 33 of the outer tube 32, causing the needle-holding tube 343 to securely grab the needle 25 once accepted. The spring 38 is disposed inside the outer tube 32 so as to provide a backward biasing force on the inner member 34. In other words, the inner member 34 is normally in a backward position inside the outer tube 32 under the influence of the backward biasing force of the spring 38 thereon. As the user pushes the inner member 34 forward by operating the knob 341 against aforementioned backward biasing force of the spring, the front part of the needle-holding tube 343 protrudes farther outward from the front opening 33 of the outer tube 32 and the slit 35 opens wider, its front opening becoming wide enough to accept the back part of a needle (away from its tissue-piercing sharp point). If the user then releases the force being applied to the knob 341 after the back part of the needle 25 has been accepted inside the slit 35, the backward biasing force by the spring pushes the inner member 34 backward, reducing the length of the needle-holding tube 343 outside the front opening 33 of the outer tube 32. This has the effect of reducing the opening of the slit 35 and hence of having the needle 25 firmly gripped by the needle holder 30. In summary, the user pushes the knob 341 forward to accept the needle 25 and releases the force on the knob

341 to firmly grab it. When a needle is already being held by the needle holder 30, the user has only to push the knob 341 to release it.

- A valve repair procedure embodying this invention, such as for
5 reducing the valve orifice by using the apparatus described above,
will be described next.

To access a mitral valve, a small incision is made on the appendage of the left atrium. One of the needles 25 of the clip assembly 20 is grabbed by the needle holder 30, as shown in Fig. 1,
10 by pushing the knob 341 forward to accept the needle 25 and then releasing it to firmly attach the needle 25 to the needle holder 30, as described above. A cannula is inserted into the incision. Fig. 1 shows the cannula schematically at 40 but the patient's body part are omitted from Fig. 1. With an aid of an ultrasound machine (not
15 shown), the needle holder 30 is passed through the cannula 40 towards the leaflets, and the needle 25 held by the needle holder 30 is caused to penetrate and be completely pulled through one of the leaflets. Thereafter, the knob 341 is pushed forward to release the needle 25. The knob 341 is pushed forward again to grab the same
20 needle 25 from the other side of the leaflet to secure the needle 25 on the leaflet. Thereafter, the needle 25 is released, the needle holder 30 is pulled out of the cannula 40 and the other of the needles 25 of the double-arm clip assembly 20 is similarly grabbed by its needle holder 30. The same procedure as described above is
25 repeated to cause the second needle 25 of the clip assembly 20 to penetrate and be completely pulled through and be secured to the other of the leaflets. The needles 25 are pulled, together with the flexible members 24 attached thereto, until the clip 22 comes to span

the leaflets, as shown in Fig. 4A. Thereafter, the release mechanisms 23 are squeezed by an instrument such as the needle holder 30 itself to release the clip 22 from the flexible members 24. Free of constraints, the clip 22 now tends to return to its natural 5 closed configuration, reducing the distance separating its two end points. This has the effect of tightly bringing the leaflets together, as shown in Fig. 4B, thereby reducing the valve orifice.

The invention was described above by way of only one example but this example is not intended to limit the scope of the 10 invention. Many modifications and variations are possible within the scope of the invention. For example, although the use of a clip assembly having two needles each connected to a corresponding one of the two end points of a generally U-shaped clip was disclosed, use may be made under certain circumstances of a 15 simpler single-arm clip assembly 20' shown in Fig. 5 and described, for example, in aforementioned U.S. patent applications Serial Nos. 09/089,884 and 09/090,305, having only one needle 25 attached through a flexible member 24 and a release mechanism 23 to one of the two end points of a clip 22'. Such a single-arm clip assembly 20' 20 may be used similarly, as described above in connection with the double-arm clip assembly 20 shown in Figs. 1 and 2, except that the clip 22' is provided with a stopper 26 at the other of its two end points not connected to the flexible member 24 for keeping the clip 22' in its generally U-shaped open configuration. After the needle 25 is 25 caused to penetrate both leaflets, as shown in Fig. 6, the clip 22' can be caused to pull the two leaflets together as the flexible member 24 is pulled, the stopper 26 serving to locate the clip 22' across the leaflets.

The section of International Application No. PCT/US99/12566 from page 10, line 10 through page 11, line 21, which section and accompanying Fig. 1 is hereby specifically incorporated by reference herein) as a further description of a single-arm clip assembly.

5 Fig. 7 shows still another clip assembly 20" embodying this invention, indicating like components by the same numerals as used in Figs. 2 and 5. This clip assembly 20" is characterized as having not only two tissue penetrating needles 25 each connected to a flexible member 24 but also two self-closing clips 22' as shown in
10 and explained with reference to Fig. 5, each having a stopper 26 at one end point for keeping the clip 22' in a generally U-shaped open configuration and the other end point being connected to a corresponding one of the flexible members 24 through a release mechanism 23 for separating the clip 22' from the flexible member 24
15 and thereby releasing the clip 22' from remaining in its open configuration. These two clips 22' are connected through their stoppers 26 by another flexible member 29 which may be a suture or a metal wire.

A clip assembly 22' thus structured may be used in a valve
20 repair procedure, for example, by penetrating a leaflet tissue with one of the needles 25, causing it to come up and out at another position in a manner of ordinary stitching, pulling the associated flexible member 24 until the clip 22' connected thereto penetrates the leaflet tissue partially such that the end point of this clip 22' on the
25 side of the release mechanism 23 penetrates the tissue and reappears on the surface while the other end point on the side of the stopped 26 does not penetrate the tissue, and doing the same with the other needle 25 on the leaflet on the opposite side of the valve

opening. After the release mechanisms 23 on both clips 22' are pressed, as described above, to release the clips 22' from the needles 25, each clip 22' tends to coil up, getting firmly attached to the respective leaflet, the flexible member 29 therebetween holding

- 5 the leaflets together, as shown in Figs. 8A and 8B. In other words, it is the flexible member 29 between the two clips 22' that holds the leaflets together. As an alternative procedure, the needles 25 may be operated such that the connecting flexible member 29 makes a loop between the leaflets, as shown in Fig. 8C.

10 The clip assembly 20" of Fig. 7 also may be used to repair or replace cordae tendinae, which interconnect the leaflets and papillary muscle by manipulating the assembly so as to place the flexible member 29 such that it extends between and interconnects papillary muscle and a respective posterior or anterior leaflet.

15 Although the clips 22 and 22', when constrained to an open configuration before they are released from the flexible member 24, are described as being generally U-shaped, this description is intended to be interpreted broadly. As should be clear from the intended function of the clips 22 and 22', their open configuration
20 may look more like a C or a J than a U. The release mechanisms 23, described above as serving to release the connection between the clip 22 or 22' and the flexible members 24 and to release the clip 22 or 22' from its forced open configuration, may be structured as disclosed in aforementioned U.S. patent application Serial No.
25 09/260,623 (or International Application No. PCT/US99/12566, which published on December 9, 1999 under International Publication Nos. WO 99/62406), but their structure is not intended to limit the scope of the invention.

In summary, the disclosure is intended to be interpreted broadly. Although the invention has been described as being addressed to a method and an apparatus for valve repair, a person skilled in the art will immediately realize that the method and 5 apparatus of this invention as described above can be used for holding two tissue parts close together, not being limited to valve leaflets. The scope of this invention, therefore, is to be understood as including methods of and apparatus for holding two tissue parts close together.

What is claimed is:

1. A minimally invasive method of holding two tissue parts
5 together, said method comprising:

providing a clip having two end points which are separated
from each other when said clip is in an open configuration and
tending to return to a naturally closed configuration by reducing
distance between said end points when in said open configuration;

10 placing said clip across the two tissue parts such that said two
end points each penetrate completely a different one of the two
tissue parts while said clip is in said open configuration; and

allowing said clip to tend to return to said closed configuration,
whereby the two tissue parts are held together by said clip.

15

2. The method of claim 1 wherein said two end points of
said clip are each detachably attached to a tissue penetrating needle
through a flexible member, and wherein placing said clip comprises
penetrating and completely pulling one of the needles through one of
20 said two tissue parts and the other of the needles through the other
of the two tissue parts.

3. The method of claim 2 further comprising:
releasably grabbing one of said needles by a needle holder;
25 inserting a cannula through an incision towards the tissue
parts;
advancing said needle holder through said cannula with said
one needle grabbed thereby;

operating said needle holder to cause said one needle to penetrate and be completely pulled through said one tissue part from one side to the other side;

thereafter releasing said needle from said needle holder;

5 thereafter grabbing and pulling said needle again by said needle holder from the other side of said one tissue part;

thereafter releasably grabbing the other of said needles by said needle holder, advancing said needle holder through said cannula with the other needle grabbed thereby, operating said

10 needle holder to cause the other needle to penetrate and be completely pulled through the other tissue part from one side to the other side thereof;

thereafter situating said clip on both of said two tissue parts;

and

15 thereafter detaching said clip from the needles.

4. The method of claim 3 wherein said needle holder includes an outer tube and an inner member which has a front end adapted to releasably grab said needle and is slidable inside said
20 outer tube.

5. The method of claim 4 wherein said needle holder further includes a spring which is disposed inside said outer tube and serves to apply a force on said inner member backward away from
25 said front end.

6. The method of claim 1 wherein said clip comprises a wire made of a shape memory material.

7. The method claim 1 wherein said clip in said closed configuration is looped by more than 360°.

5 8. The method of claim 1 wherein one of said two end points of said clip is detachably attached to a tissue penetrating needle through a flexible member, and wherein said step of placing said clip comprises penetrating and completely pulling said needle through one of the two tissue parts and thereafter the other of the two
10 tissue parts.

9. Apparatus for minimally invasive valve repair, said apparatus comprising:

a tissue penetrating needle connected through a flexible
15 member to a clip, said clip having two end points which are separated from each other when said clip is in an open configuration and tending to return to a naturally closed configuration by reducing distance between said end points when in said open configuration; and
20 a needle holder including an outer tube and an inner member which has a front end adapted to grab said needle and is slidable inside said outer tube.

10. The apparatus of claim 10 wherein said needle is one of
25 a pair of needles, said flexible member is one of a pair of flexible members each connected to a corresponding one of said two end points of said clip, and said release mechanism is a pair of release

mechanisms each being directly attached to a corresponding one of said one end points of said clip.

11. The apparatus of claim 9 wherein said needle holder
5 further includes a spring which is disposed inside said outer tube and serves to apply a biasing force on said inner member backward away from said front end.

12. The apparatus of claim 11 wherein said front end of said
10 inner member has a slit for accepting and grabbing said needle therein.

13. The apparatus of claim 12 wherein said outer tube, said
inner member and said slit are designed such that said slit opens
15 wide enough to accept said needle therein and to release said needle therefrom if said inner member is pushed forward against said biasing force and that said slit becomes narrower and firmly grips said needle therein if said inner member is moved backward.

20 14. The apparatus of claim 9 wherein said clip is generally U-shaped when in said open configuration.

15. The apparatus of claim 9 wherein said clip comprises a wire made of a shape memory material.

25

16. The apparatus of claim 9 wherein said clip in said closed configuration is looped by more than 360°

17. A clip assembly comprising:

two clips each having two end points which are separated from each other when said clips are in an open configuration and tending to return to a naturally closed configuration by reducing distance

5 between said end points when the clip is in said open configuration;

two tissue penetrating needles each connected to one of said two end points of a corresponding one of said two clips through a flexible member; and

a flexible connector connecting the other end points of said two

10 clips together.

18. The clip assembly of claim 17 further comprising

releasing means for normally keeping said two clips in said open configuration and releasing each of said two clips to become

15 separated from the associated flexible member to thereby allow said clips to begin returning to said closed configuration.

19. The clip assembly of claim 17 wherein said clips

comprise a wire made of a shape memory material.

20

20. A minimally invasive method of holding two tissue parts together, said method comprising:

providing a clip assembly which comprises two clips each having two end points which are separated from each other when

25 said clips are in an open configuration and tending to return to a naturally closed configuration by reducing distance between said end points when the clip is in said open configuration, two tissue penetrating needles each connected to one of said two end points of

a corresponding one of said two clips through a flexible member, and a flexible connector connecting the other end points of said two clips together;

penetrating and completely pulling one of the needles through

- 5 a tissue part and penetrating and completely pulling the other of the needles through an adjacent tissue part while said clips are each in said open configuration;

pulling the needles until each of said clips is hooked to a

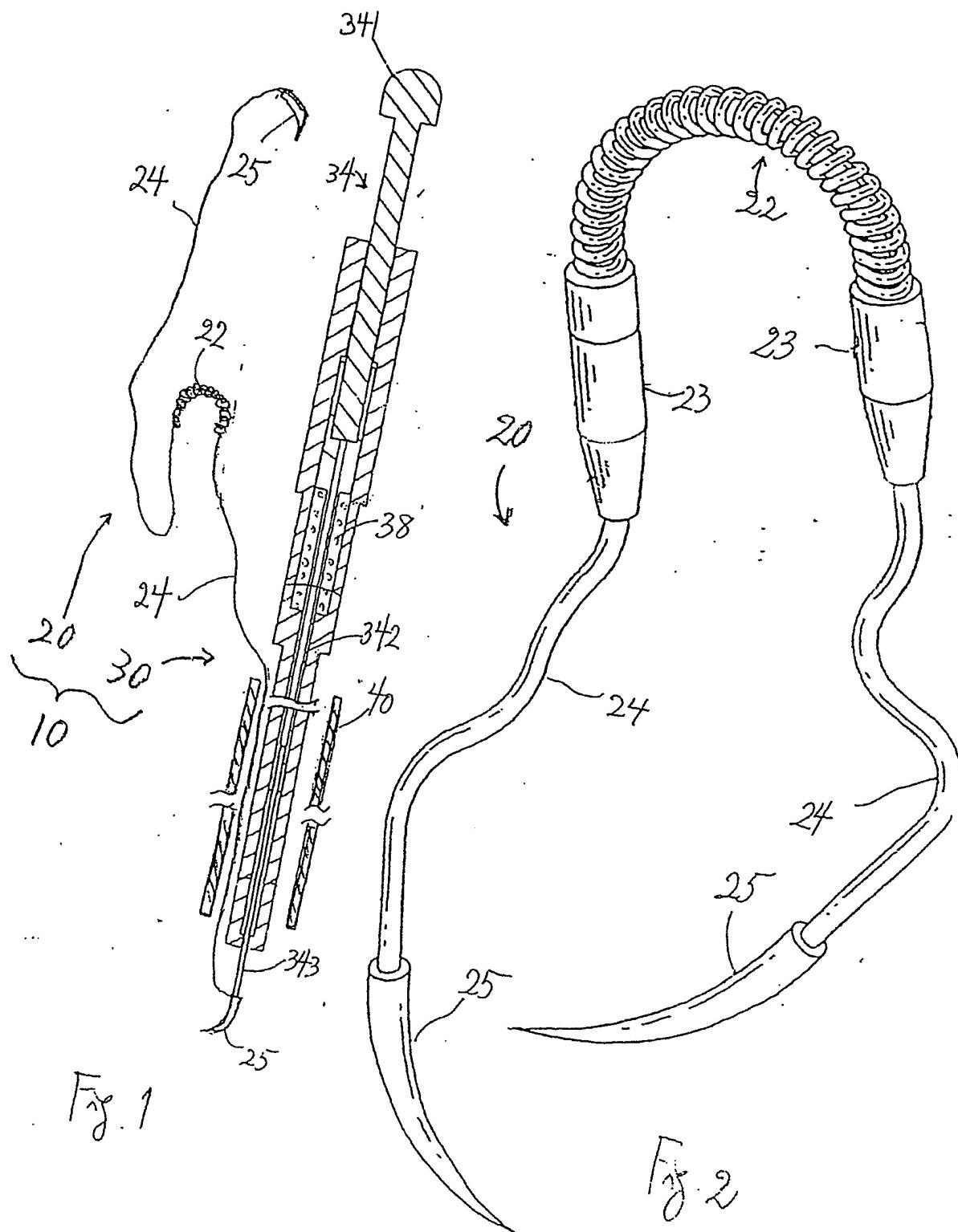
corresponding one of the tissue parts; and

- 10 allowing said clips to start to return to said naturally closed configuration, whereby said two tissue parts are held together by said flexible connector stretched between said clips.

21. The method of claim 20 wherein said clip assembly

- 15 further comprises releasing means for normally keeping said two clips in said open configuration and releasing each of said two clips to become separated from the associated flexible member to thereby allow said clips to begin returning to said closed configuration, and wherein said clips are allowed to start to return to said naturally
- 20 closing configuration by separating said clips from said needles through said releasing means.

22. The method of claim 20 wherein said clips comprise a wire made of a shape memory material.



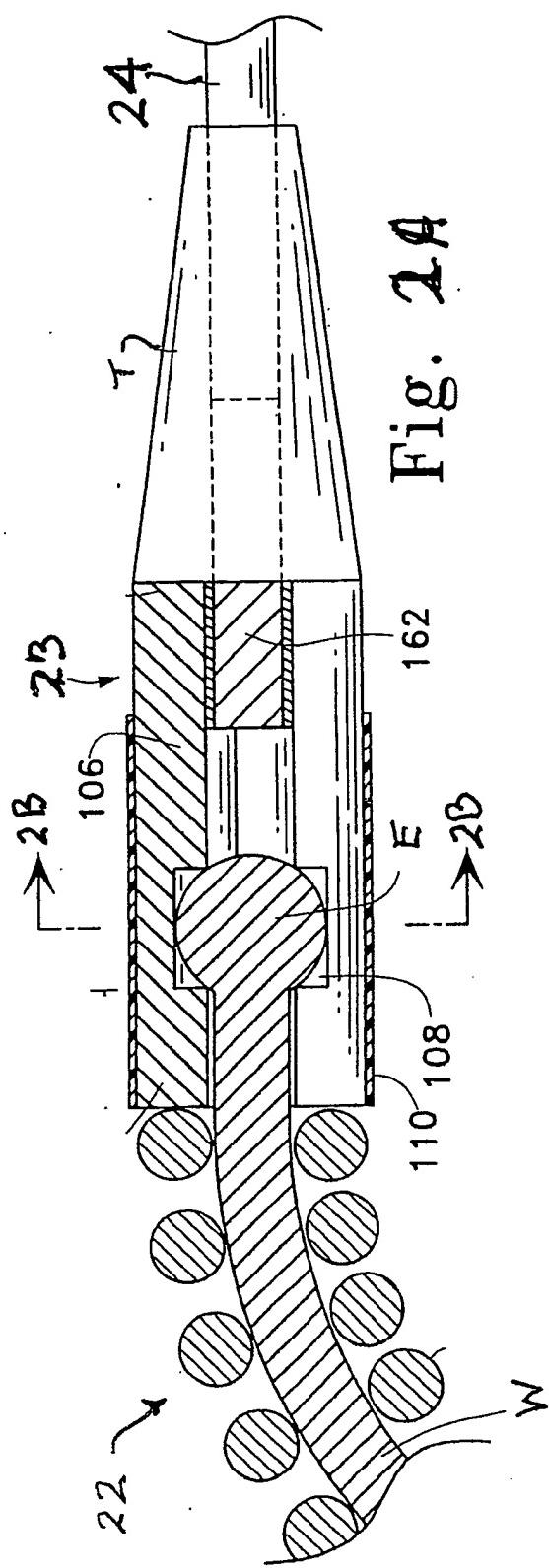
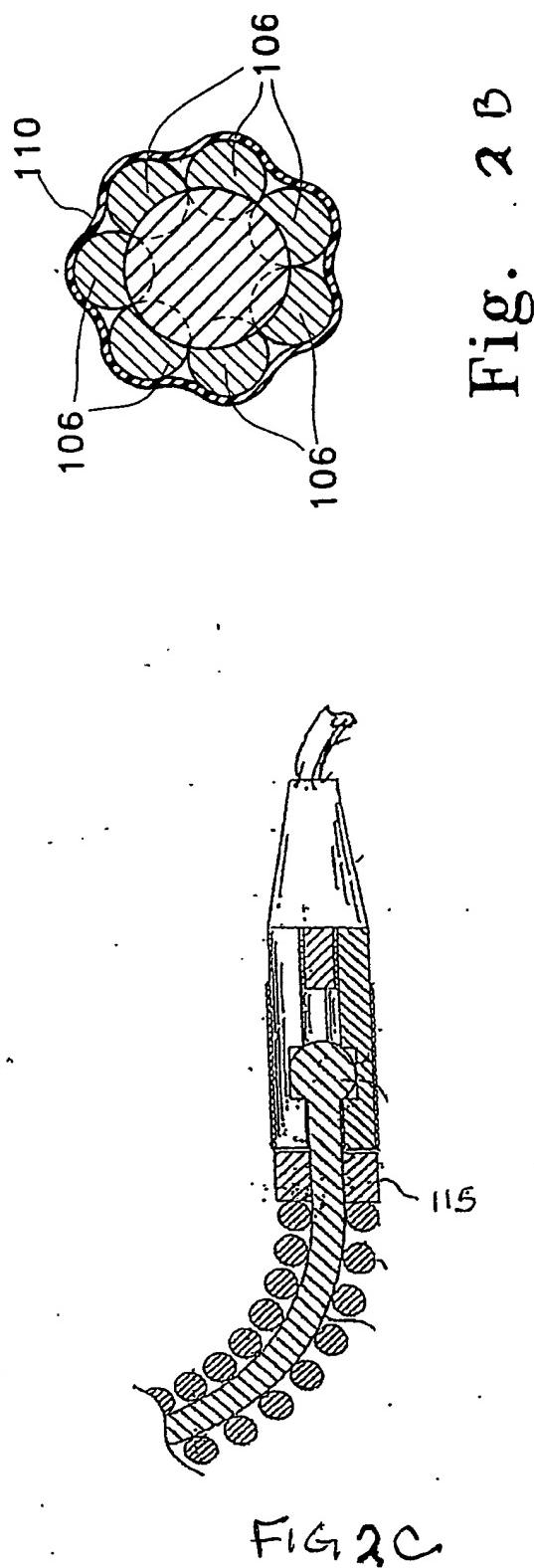


Fig. 2A



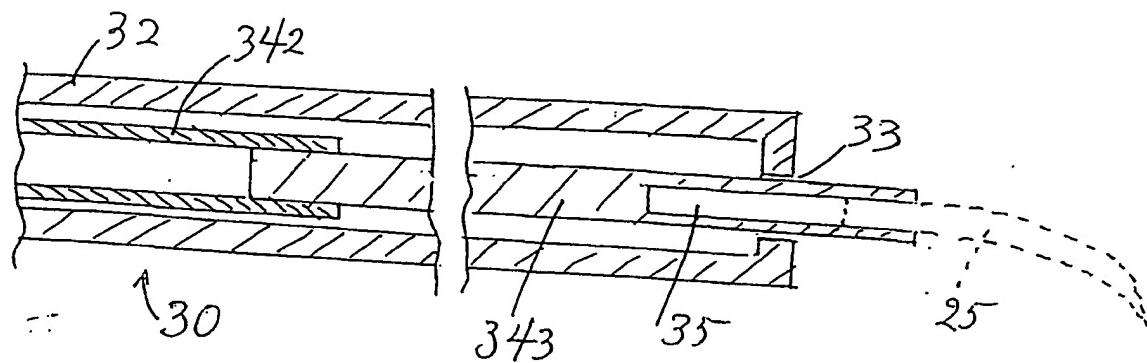


Fig. 3

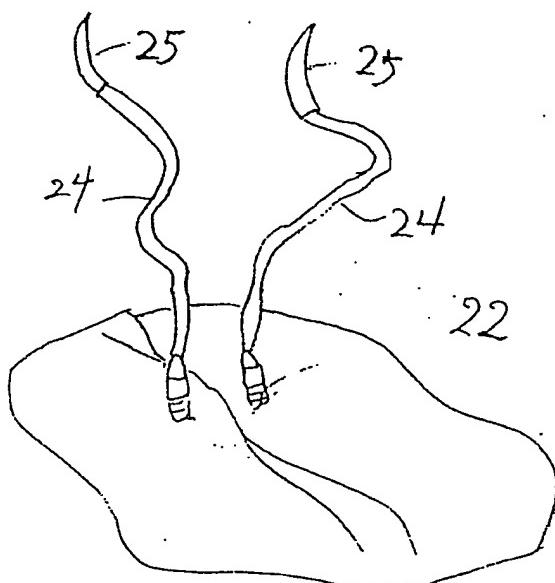


Fig. 4A

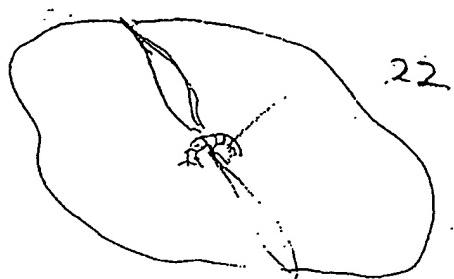


Fig. 4B

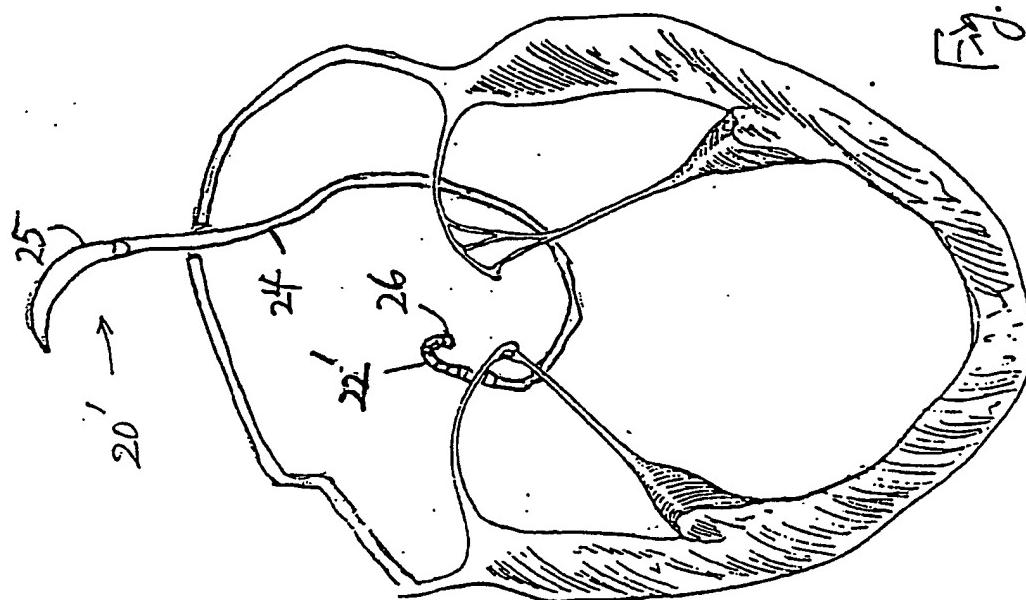


Fig. 6

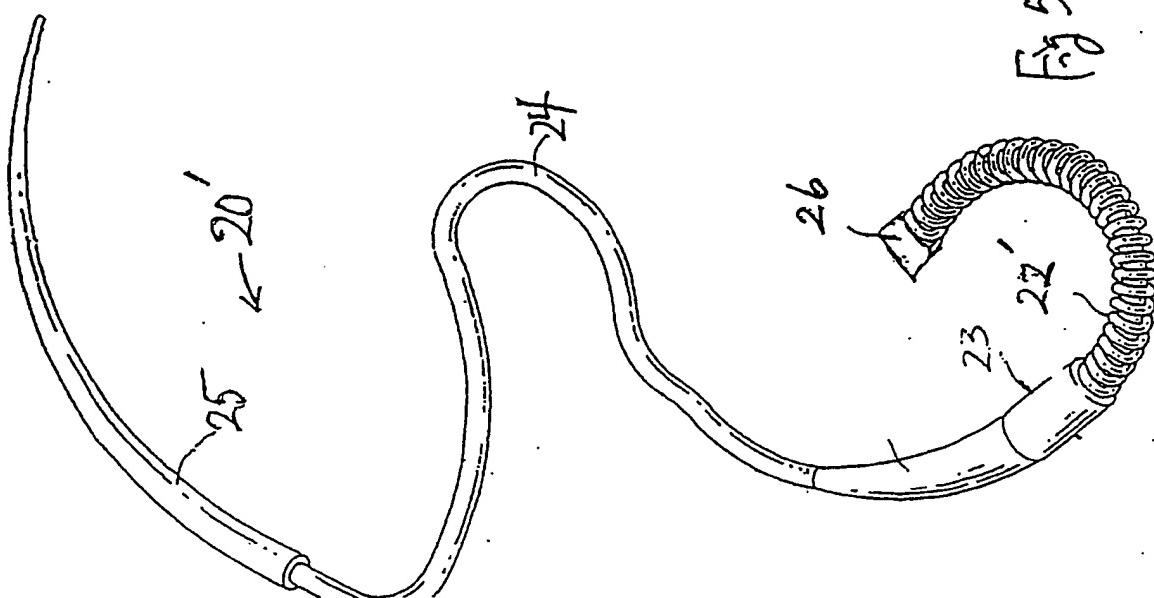


Fig. 5

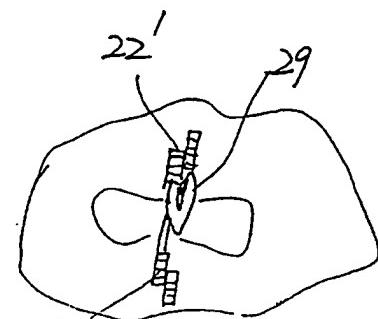
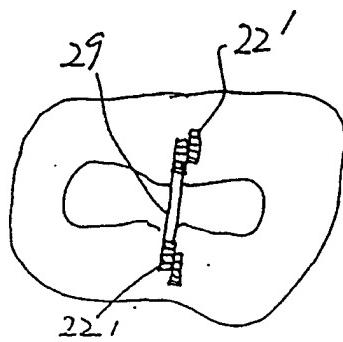
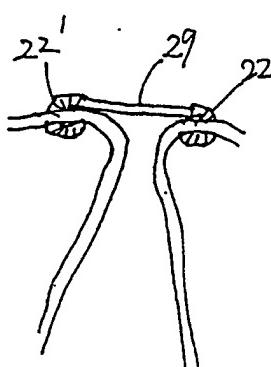
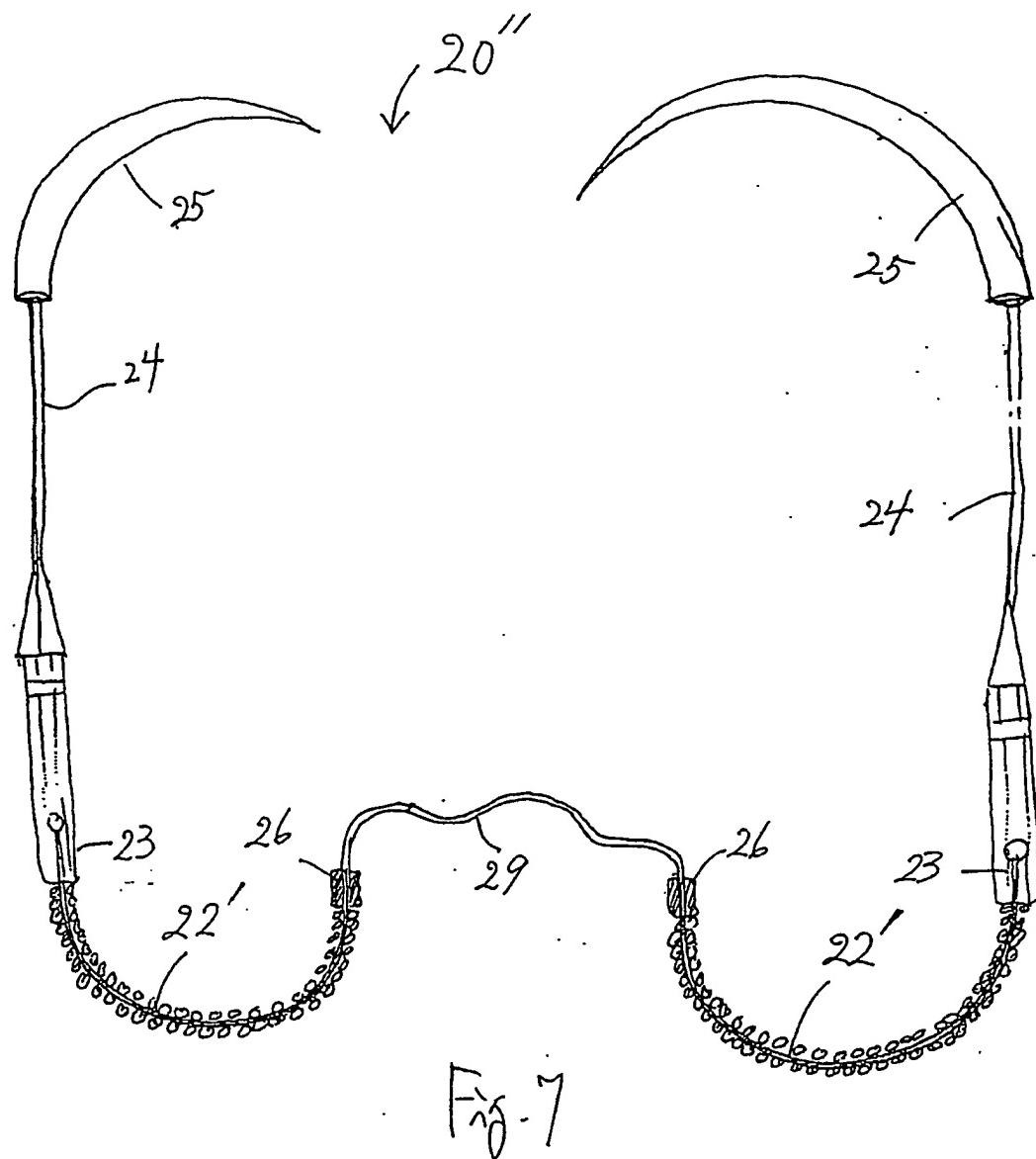


Fig. 8A

Fig. 8D

Fig. 8C

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US01/31709

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) :A61B 17/04, 17/08
US CL :606/228, 232, 233, 222-225, 219, 151-158

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 606/228, 232, 233, 222-225, 219, 151-158

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EAST

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6,193,733 B1 (Adams) 27 February 2001 (see figures 8a-11d; col. 5-6, lines 1-67).	1, 6 and 7
A	US 5,002,563 A (Pyka et al.) 26 March 1991 (see figures 1-8b).	
X	US 5,989,268 A (Pugsley, Jr. et al.) 23 November 1999 (see figures 1-3f).	1 and 6

Further documents are listed in the continuation of Box C. See patent family annex.

* Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A" document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E" earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document; member of the same patent family
"O" document referring to an oral disclosure, use, exhibition or other means		
"P" document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search	Date of mailing of the international search report
12 NOVEMBER 2001	17 JAN 2002
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20251 Facsimile No. (703) 305-3290	Authorized officer (JACKIE) TAN-UYEN THI HO <i>Diane Smith</i> Telephone No. (703) 306-3421